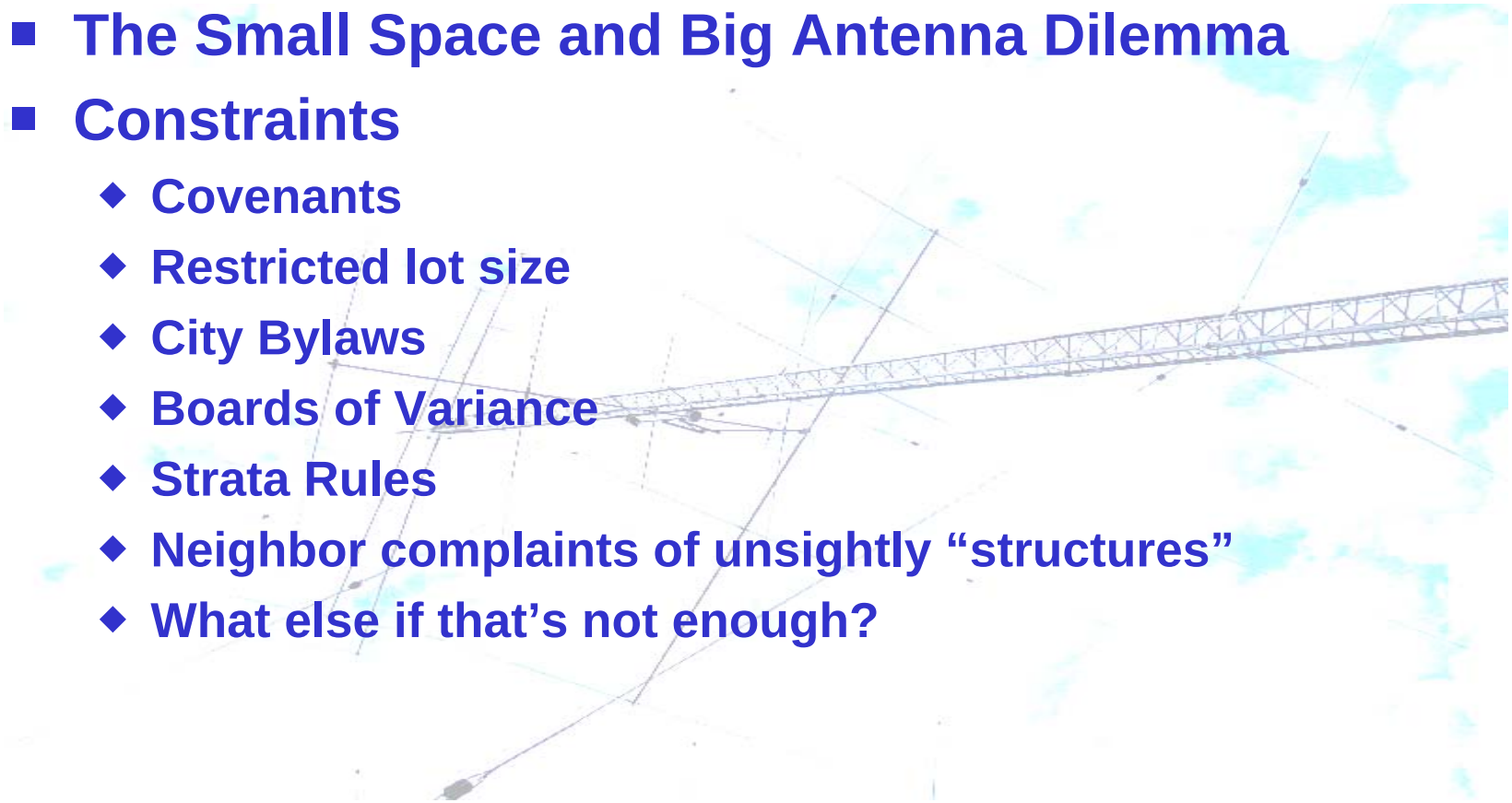
Small HF Antennas

-•-• --•- -•• • •••- • --••• -• ••• •-•

- **The Small Space and Big Antenna Dilemma**
- **Constraints**
  - **Covenants**
  - **Restricted lot size**
  - **City Bylaws**
  - **Boards of Variance**
  - **Strata Rules**
  - **Neighbor complaints of unsightly “structures”**
  - **What else if that’s not enough?**



The Challenge

- • – • – – • – – • • – • • • • – • – – • • • – • • • • – – • • • • • – • • • • • • • – • • • • • • • • • – • – • •

- **How to make HF antennas perform in small spaces**
- **Small antennas**
  - **Small means shorter antennas that fit available space**
- **How to make Stealth antennas**
  - **Ant's that are visible but don't look like antennas**
- **How to Hide antennas**
  - **Out of sight but somewhere in/on the housing structure**

Operating Issues

- • - • - - • - - • • • • - • - - • • • • - • • • - • - - • • • • - • • • • - •

- **Performance issues using short antennas**
  - **Lower gain – less “wire in the sky”**
  - **Narrower bandwidths – tuning required**
  - **Non-50 ohm feed point impedances – tuner needed**
- **Interference more likely**
  - **Proximity to audio, video, AM, FM, PC, Tel, etc equipment**
  - **QRP to 100 watts probable max**
- **Safety issue**
  - **You and the antenna may share the same space**
  - **RF biological exposure limits to be checked**
  - **Structural integrity of mounted antennas – make secure**

Building RF Transparency

- • - • - - • - - •• • • • • - • - - • • • - • • • • • - •

- **Conducting materials at ½ wavelength spacing**
- **Wooden frame structures**
  - **RF transparency - good**
  - **Internal conductors – "antennas"**
    - **Power, telephone, cable, alarm etc wiring**
    - **Copper plumbing**
- **Concrete structures**
  - **RF shielded at HF**
    - **Rebar and metal framed windows – small aperture**
    - **Metal 2 x 4 framing inside building**
    - **Internal conductors**

Which Floor? Apt / Condo

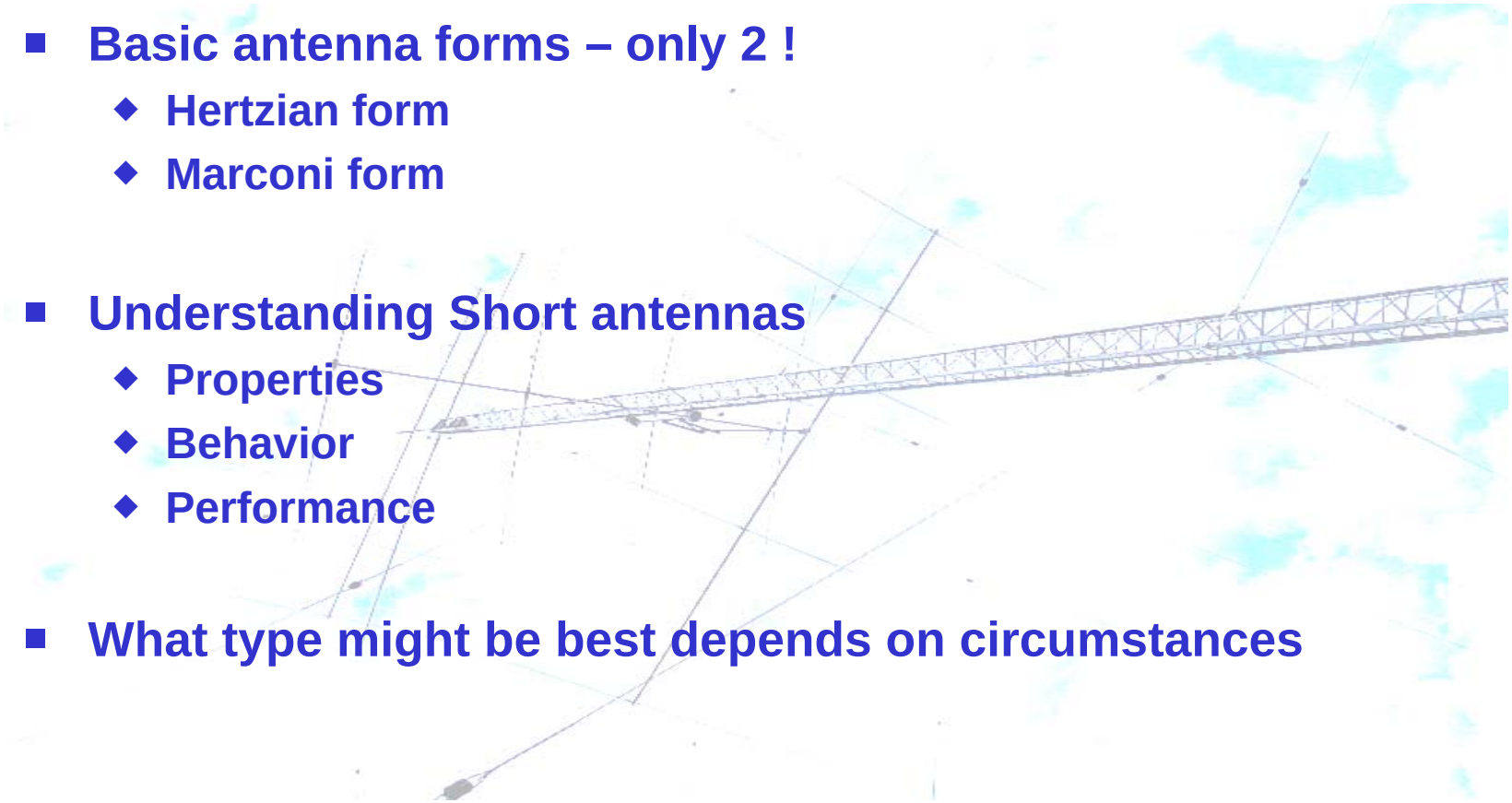
- • – • – – – • – – • – – • • • – • – – • • • – – • • • • • •

- **Top floor**
  - **access to roof top antennas**
  - **short feeder runs**
  - **best separation from tenants, none above**
- **Bottom**
  - **access to ground mounted antennas**
  - **grounding systems possible**
  - **feeder runs OK**
  - **tenant spacing, top & 2 sides**
- **Mid floors**
  - **interior or balcony mounted antennas**
  - **tenants all around**

Some Antenna Theory

- • – • • – – • • • – • – – • • • • – • • • • • – • • • • – • • • – • – •

- **Basic antenna forms – only 2 !**
  - **Hertzian form**
  - **Marconi form**
- **Understanding Short antennas**
  - **Properties**
  - **Behavior**
  - **Performance**
- **What type might be best depends on circumstances**

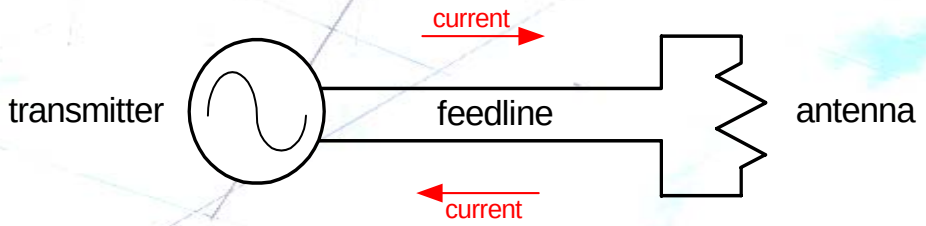


Antenna Circuit

- • - • - - • - - - • • • - • - - • • • - - • • • • • - •

- **Generator – the transmitter**
- **Feedline – two conductors**
- **Antenna – two wires**
- **Antenna as R = radiation resistance at resonance**

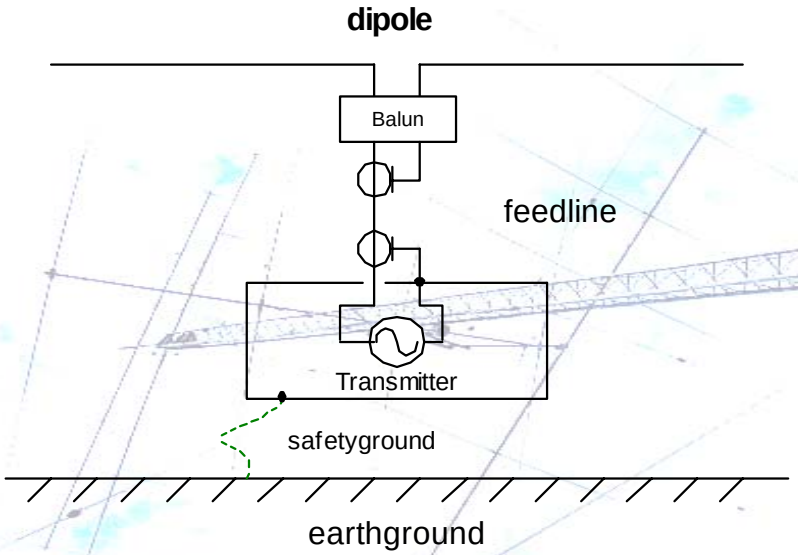
- **Complete the circuit - current must flow entirely around the loop**



Hertzian Antenna

- • - • - - • • - • • • - • - - • • • - • • • • - •

- **No earth connection required for Antenna – good!**
- **Antenna radiates independent of ground**



Dipole, half wave

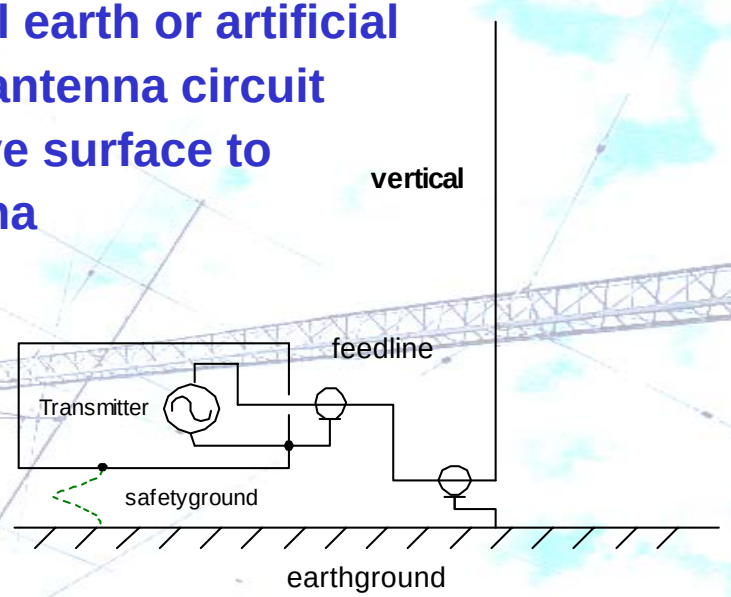
- **Rig grounded by green wire in power cord - SAFETY**
- **This ground is not part of the antenna system.**

Marconi Antenna

- - - • - • - - - • - - • • • • - • • - • - - • • • - • • • • - •

- Antenna operates “against” ground.
- Ground circuit is required – real earth or artificial
- Ground is the other half of the antenna circuit
- Ground consists of a conductive surface to mirror the top half of the antenna

Vertical quarter wave



- Rig grounded by green wire in power cord - SAFETY
- Safety ground could become part of antenna system
- Not desirable

Standard Antenna

to which most other antennas are compared

- • - • - - • - - - • • • • - • - - • • • - - • • • • - •

- **Resonant Half Wave dipole**
- **At resonance, feed point ~ 50 ohms (radiation resistance)**
  - **Good match to 50 ohm coax**
  - **Low VSWR**
  - **Maximum power transfer from rig to antenna**
- **Short antenna performance measured against this**
  - **gain, impedance, bandwidth,**

Short Antenna Properties

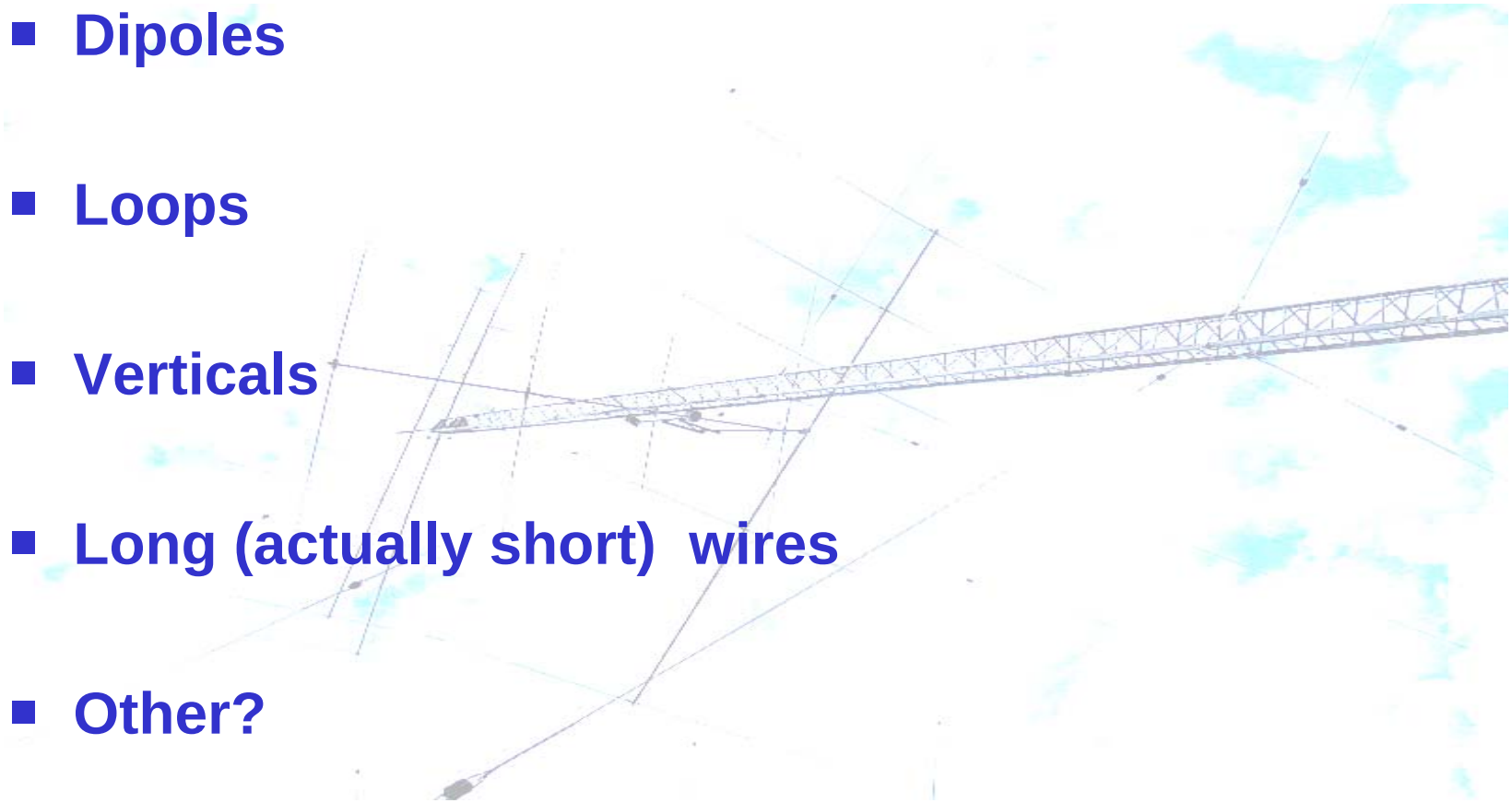
- • – • – – • • – • – • • • • – • – – • • • – • • • • – • • – • • • – • – • •

- Antenna no longer resonant at desired frequency
- Antenna gain is reduced due to shortness
- Feed point impedance changes
  - radiation resistance drops significantly
  - capacitive reactance appears at the feed point
  - feedline matching becomes poor and & high VSWR results
- Efficiency drops
  - ohmic losses become a significant part of the feed point Z

Solutions

- - - . - - - . - - . . . . . - . - - . . . - . . . . . - .

- **Dipoles**
- **Loops**
- **Verticals**
- **Long (actually short) wires**
- **Other?**



Restore Resonance

- • - • - - • - - - • • • - • - - • • • - - • • • • • • • - • - • • •

- **Short antenna “looks” capacitive**
- **Restore feed point impedance to look resistive**
- **Add an inductor somewhere “in” the antenna**
  - **nulls out the capacitance – creates resonant circuit**
  - **used with both dipoles & verticals**
- **Add a capacitor to the end of antenna**
  - **make antenna look longer (electrically) than it is**
  - **used most often with verticals**

Use an External Tuner

- . - - . - - . - - - - . - - . . . . - . - - . . - - . . . . - . - .

- Antenna is not brought back to resonance
  - no inductive or capacitive loading added
- Tuner matches complex antenna feed point impedance to 50 ohm output of transmitter
- Useful for multi-band operation
- Tuning limitations may be evident if tuner cannot match the antenna / feed line impedance.
- Rig tuners not well suited to off–resonant antennas

Loading Coils

- • – • – – • – – • • • – • – – • • • – – • • • • • – • • • • – •

- **Loading Coils are inserted in series with antenna**
  - **“makes up for shortness”**
- **Spi-Ro Manufacturing offers “Shortners”**
  - **http://www.spiromfg.com/**
- **Cancels the Capacitive component**
- **Resonates the antenna**
- **Coil placement**
  - **Dipoles – one in each leg**
  - **Verticals – one towards or at the bottom**

Coil Loaded Dipole

- • - • - - • - - - • • • • - • - - • • • - - • • • • - •

Loading Coils (2) – “Shortner”

Balun

- **Balanced system**
- **Single band**
- **No ground issues**
- **Reduce lengths**
  - **80m dipole from 132 ft to 69 ft**
  - **40m dipole from 66 ft to 38 ft**
  - **most likely an outdoor application**
- **Radio tuner ought to be OK**

http://www.spiromfg.com/

Wire Antennas

- • - • - - • - - - • • • - • - - • • • • - • • • • - • - - - • • • • - • • • • • - • • • • • - •

Compact Dipoles

- • - • - - • - - • - - • • • • - • - - • • • - - • • • • - •

- **Ventenna**
  - **20 to 10m**
  - **80 & 40m options**
  - **length unknown**
  - **http://www.ventenna.com/hfp-dipole.html**

- **Buddipole**
  - **40 to 2m**
  - **coil loaded**
  - **collapsible**
  - **16 feet extended**
  - **http://www.buddipole.com/**

Compact Vertical

- • - • - - • - - - • • • • - • - - • • • - • • • - • • • •

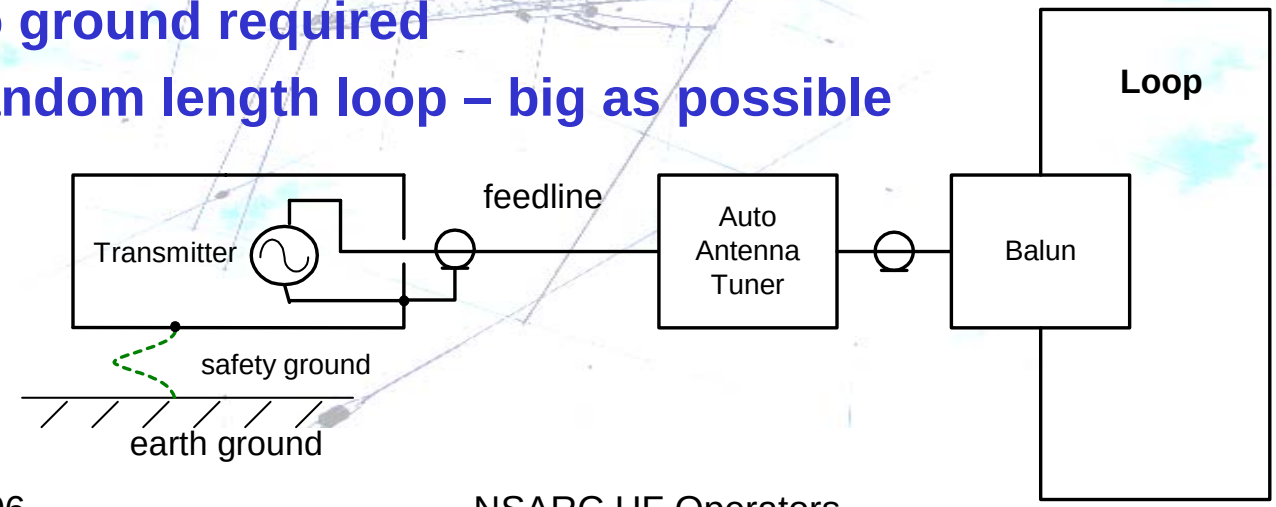
MFJ Loop Antenna

-... --.- -.. . ...- . -.... -. ... .-.

- Small and very suitable for apartments
- 36 inch diameter
- No ground system required
- MFJ-1786 20 thru 10m
- MFJ-1788 40 thru 15 m
- Good performance reviews on eHam
- Low noise advantage
- Self tuning – no external tuner needed
- Inside or outside dwelling

Wire Loop Antenna

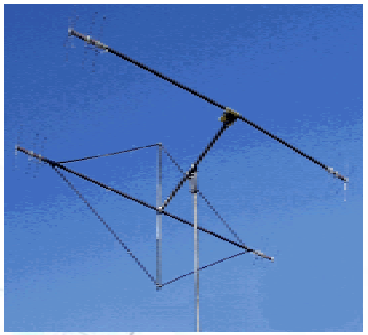
- Home made - construct wire loop
- Could reside inside dwelling
- Hang horizontal or vertical
- Requires external tuner & balun
  - LDG Z-100 tuner + RBA balun
  - http://www.ldgelectronics.com
- No ground required
- Random length loop – big as possible



Compact Yagi's

- • – • – – • – – • – • • • – • – – • • • – • • • • – •

- **Hybrid Quad**
  - **Model MQ-1**
  - **20 thru 6m**
  - **11 ft elements / <5 ft boom**
  - **http://www3.sympatico.ca/**
- **G4MH Mini Beam**
  - **10 /15/ 20m 3 element**
  - **2m boom / 5m elements**
- **ZX Mini-2000 Beam**
  - **10/15/20m 3 element**
  - **3m boom / 3.4m elements**



- **Both at http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=4044**

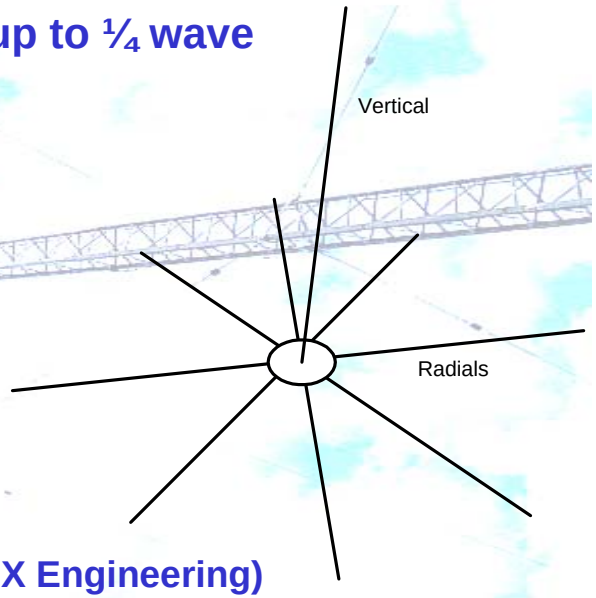
Vertical Antennas

- • – • – – • – – • • • – • – – • • • – – • • • • • • • – •

- **Verticals are unbalanced antennas**
- **Require a ground plane or counterpoise**
- **Copper plumbing and Safety ground wiring NOT a good choice for RF ground / counterpoise.**
- **Mounting possible off balconies, rooftops or at ground level**
- **Inside a dwelling, maybe not so practical**

Radial System
Multiwire

- A system of wires at base of vertical
  - minimum 2 per band if using multi band vertical
  - single band, try for 8 as long as possible, up to ¼ wave
- Lay radials out symmetrically as possible
- Bend ends to fit, no bends at base
- Lay radials on surfaces
  - roof, hold in place with bricks
  - lawns - trench and bury (staples avail. from DX Engineering)



Counterpoise

Single Wire

-•-• --•- -•• • •••- • --••• -• ••• •-•

- **A conductor(s) used as a substitute for earth or ground in an antenna system.**
- **Usually just one or two wires**
- **Counterpoise will have RF on it and will radiate**
- **Undefined operation if using building copper pipe or safety ground wiring as counterpoise.**
- **MFJ-931 Artificial Ground – loads a short counterpoise**

Coil Loaded Vertical

-... --.- -.. . ...- . -.... -. ... .-.

- **Coil at base = feed point**
- **Intended for mobile applications**
- **Uses car body as counterpoise**
- **Use as base with a radial or counterpoise system**

http://www.mfjenterprises.com/

~ 5 feet high
Change bands by
Moving tap on coil

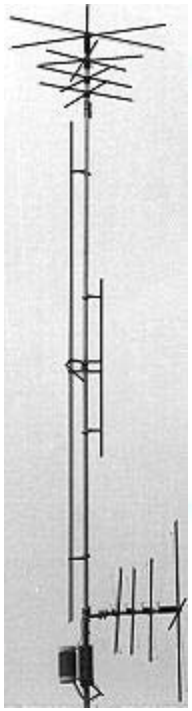
Capacity “Hats”

-.-. --.- -.. . ...- . -....- -. ... .-.

- **Capacity “Hat” placed at end (top) of antenna**
- **Resonates the antenna**
- **Removes the Capacitive component**
- **Placement most effective at end of antenna**

Capacity “Hats”

- • - • - - • - - • • • • • • - • - - • • • - • • • • • - •



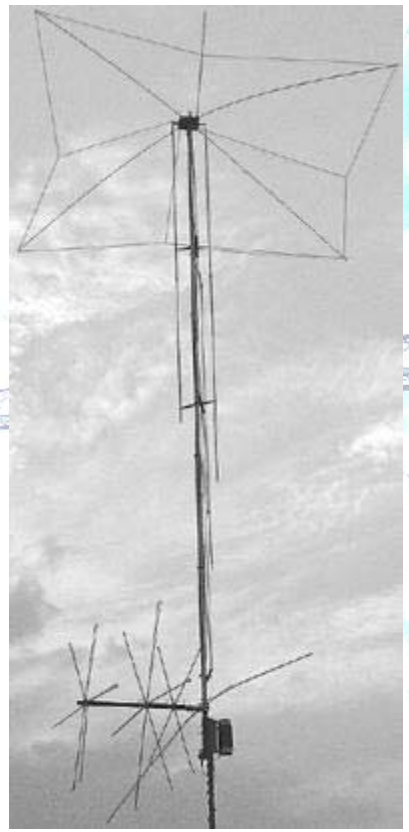
MFJ-1796

Capacity Hat

40 thru 2m
No Radials
Feed line balun

12 feet high
24” footprint

80/40m
Needs, guys & radials
33 feet high



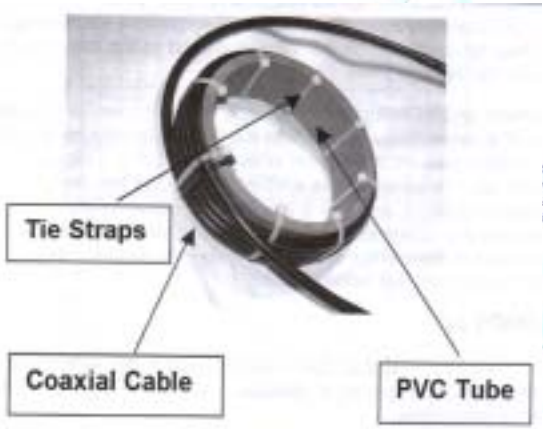
MFJ-1792

http://www.mfjenterprises.com/

Current Baluns

- • - • - - • - - - • • • • - • - - - • • • - • • • - • • • • - •

- Coax feedline to vertical – use a current choke / balun
- Keep RF from flowing on coax & entering shack
- Isolates rig / ant from safety ground
- Coax coil choke
  - CQ magazine Oct 2006 pg 44
- Snap On chokes
  - RF Parts or DX Engineering
  - http://www.dxengineering.com/
  - http://www.rfparts.com/choke.html
- Ferrite Beads
  - Palomar Engineering model BA-8
  - http://www.palomar-engineers.com/



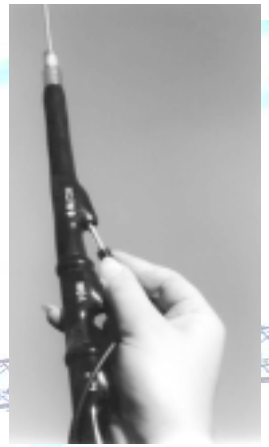
Some Vertical Antennas

-•-• ---• -•• • •••- • -••-- -• ••• •-•

- **Trap**
  - Good for ground mount or flat roof
  - to 30 ft high
  - Requires ground system
  - Multi-band 80 thru 10m
  - MFJ http://www.mfjenterprises.com/
  - Hygain http://www.wb0w.com/hygain/hygain.htm
- **Screwdriver**
  - Motorized, tuneable
  - Multiband, fully resonant 80 – 10m
  - Extends to ~ 9 ft, some shorter
  - Requires ground system
  - High Sierra http://www.cq73.com/
  - Tarheel http://www.tarheelantennas.com/home

More Vertical Antennas

- **Mobile Whip**
  - **Require ground system**
  - **Ham Sticks, monoband, ~ 6 ft**
    - **http://www.hamstick.com/**
  - **Outbacker multiband ~ 7.5 ft**
    - **Use Outpost tripod for ground mounting**
    - **http://www.alphadeltacom.com/pg9.htm**
  -



- **Balcony Verticals**
  - **Designed for balcony mount**
  - **Require ground system**
  - **~ 6 ft**
  - **Multiband 40 – 10m**
  - **MFJ 1622**
  - **B&W AP-10A http://www.bwantennas.com/**

Radials / counterpoises generally required.

Balcony Mounted

- • – • – – • – • • • – • – – • • – – • • • • • • – • • • – •

- **Short verticals mounted on railings**
  - **Metal railings as counterpoise**
  - **Wooden railings, run counterpoise wires on wood or on floor; cover with mat**
- **Longer verticals**
  - **Painter pole, retractable, telescoping “mast”**
  - **Mobile whips**
  - **June 2006 TCA**

HF Stick

HF Mount

More Balcony Mounts

- • – • – – • – – • • – • • • • – • – – • • • – • • • • – – • • • – • • • • – •

- http://www.eham.net/forums/AntennaRestrictions
- Pigeon “preventors”
- Ideas, reviews, comments ….

Long Wire Antennas

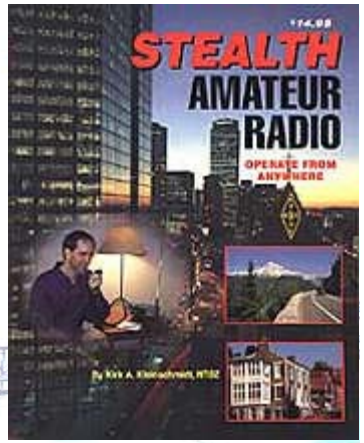
- • – • – – • – – • – • • • – • – – • • • – • • • • – •

- **Random lengths of wire – long as possible**
  - **easy to build – string outdoors, #22 insulated black**
  - **need to support two ends**
- **Typically non resonant**
- **Usually end fed – high Z point**
- **Must have a tuner (other than rig)**
- **Tuner must have a “ground” or counterpoise connection**

Stealth

- • – • – – • – – • – • • • – • – – • • • – • • • • – •

- ARRL Book
- Flagpole Verticals – ground mounted
- Wires lying on roof tops
  - Black insulation, small dia, #22
- Wires on Gable ends
  - No good under AL eaves with AL gutters
- Wires on Fences - Loops
- Attics for yagi's
- VHF/UHF on short mast looks like TV antennas
- Vent pipe VHF/UHF verticals, roof mounted
  - Ventnna

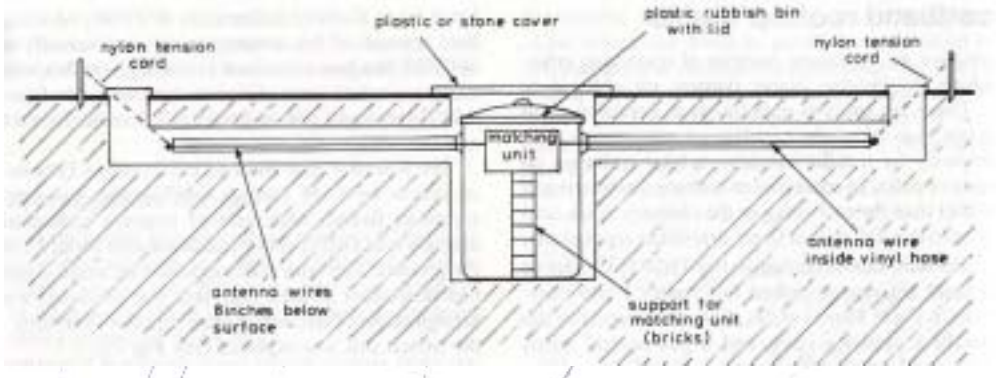


Subsurface Dipole

Really ??

- • - • - - • - - • • • • • • - • - - • • • - • • • • • - •

- **If on ground floor and able to trench the yard**
  - **Buried ~ 8 inches**


plastic or stone cover
plastic rubbish bin with lid
nylon tension cord
nylon tension cord
matching unit
antenna wire inside vinyl hose
antenna wires 8inches below surface
support for matching unit (bricks)

- **Reported 16dB less gain**
  - **~ 3 S points less than a comparable, low dipole**
- **Rather "experimental"**

Safety

- - - . - - - . - - . . . . . - . - - . . . - . . . . . - .

- **Exposure to RF fields**
  - **Biological heating**
  - **Safety Code 6 – Canadian Standard**
    - **http://strategis.ic.gc.ca/epic/internet/insmt-gst.nsf/en/sf01635e.html**
  - **Exposure Factor - closeness to antenna**
  - **Exposure Factor - transmitter power levels**
- **Antenna Voltages**
  - **RF burns from ends of antennas**
  - **“Hot” grounds at unknown locations if safety ground or plumbing used as counterpoise**

Exposure Calculation

- Approximates Safety Code 6 – uncontrolled environment
- Calculate safe field strength

  http://n5xu.ae.utexas.edu/cgi-bin/rfsafety.cgi

Calculate Radio Frequency Power Density

What is the average power at the antenna: 20
In watts

What is the antenna gain in dBi: 0
Enter 2.2 for dipoles; add 2.2 for antennas rated in dBd

What is the distance to the area of interest: 5
From the center of the antenna, in feet

What is the frequency of operation: 20
In MHz

Do you wish to include effects of ground reflections? ☐ Yes ☉ No

Calculate RF Power Density | Reset Values

Calculation Results

Average Power at the Antenna	20.000 watts
Antenna Gain in dBi	0.00 dBi
Distance to the Area of Interest	5.00 feet
Frequency of Operation	20.000 MHz
Are Ground Reflections Calculated?	No
Estimated RF Power Density	0.0686 mw/cm^2

	Controlled Environment	**Uncontrolled Environment**
Maximum Permissible Exposure (MPE)	2.25 mw/cm^2	0.46 mw/cm^2
Distance to Compliance From Center of Antenna	0.92 feet	2.00 feet
Does the Area of Interest Appear to be in Compliance?	yes	yes

Summary

- Consider balanced antenna systems first
- Verticals work will work but require radials or counterpoise
- Long wires will work but require counterpoise
- Try and get the antenna outside somewhere
- Do not create a ”special” station RF ground – the radial or counterpoise is your RF ground
- Keep antenna away from metallic objects
  - Aluminum window frames
  - Service entrance
- If moving, choose antenna friendly site